Robust growth of herringbone carbon nanofibers on layered double hydroxide derived catalysts and their applications as anodes for Li-ion batteries

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Well arrangement of sp² carbon layers leads to one-dimensional (1D) carbon nanotubes (CNTs) or nanofibers, two-dimensional (2D) graphene nanosheets and three-dimensional (3D) nanostructured carbon with unexpected properties for unique applications. The key issue for the successful applications of nanocarbon lies in the ability to pack the sp² carbon layers into the required nanostructures. When the sp² carbon sheets are packed into 1D nanocarbons, platelet carbon nanofibers (CNFs), herringbone CNFs, and cylinder CNTs are available.

In this contribution, herringbone carbon nanofibers (CNFs) were efficiently produced by chemical vapor deposition on Ni nanoparticles derived from layered double hydroxide (LDH) precursors. The as-obtained CNFs with a diameter ranging from 40 to 60 nm demonstrated herringbone morphologies when they grew on Ni/Al LDH derived catalysts both in the fixed-bed and fluidized-bed reactor (Fig. 1). The Ni/Mg/Al, Ni/Cu/Al, as well as Ni/Mo/Mg/Al catalysts were also effective to grow herringbone CNFs. The diameter and specific surface area of the as-obtained CNFs highly depended on the catalyst composition and the growth temperature. When CNFs were grown at 550 °C on Ni/Al catalyst, the as-obtained products had an outer diameter of ca. 50 nm and a specific surface area of 242 m²·g⁻¹, possessed a discharge capacity of 330 mAh·g⁻¹ as the electrode in a two-electrode coin-type cell. With the increase of the surface area, the discharge capacity increased at a rate of 0.90 mAh cm⁻², while the initial coulombic efficiency decreased gradually on nanocarbon anodes. This is attributed to the fact that CNFs with higher surface area afford smaller sp² carbon layer that facilitated more Li ions to extract from the anodes.

Fig. 1. The high magnification TEM images of the (a) NA-500, (b) NA-550, (c) NA-550F, and (d) NA-650 herringbone CNFs.